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FOOD SAFETY MANAGEMENT IN SCHOOL CANTEENS

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CONTENTS

1. INTRODUCTION, GOALS

The choice of this topic was mainly based on how important sustainable eating habits and food safety is nowadays over the World. This area is the central topic of the sustainable development goals selected by the United Nations.

1.1. Topic actuality

Megatrends are fundamental tendencies that will have a significant effect in mid- and long-term on the World. Such is global food security, affected by several environmental, social, economic and political impacts. The significant increase of food production causes challenges for global food security. These challenges are influenced by several factors. The assumed 100% increase in food demand and the internationalisation of food trade can be considered as the most notable challenges, and opportunities of the next few decades. However, this would increase the risk of food borne diseases.

Nowadays, science, healthcare, gastronomy and industry need more convergence than they ever did. Globalisation, information society and the “flat” World make information spread extremely fast. As such, apart from education, and teaching awareness in food handling, risk communication is also important in developing foodsafety. Food borne diseases are on the rise each year, and have many notable effects. Such are, apart from their impact on human life and health, negative impacts on healthcare expenditures, labour capacity, the economy, trade, and industry. Another scary thing to note is that ***food handlers are responsible for 97% of all outbreaks of foodborne diseases in the catering sector.***

In the Hungarian contract catering sector operate roughly 3500 cooking kitchens, and 6500 serving kitchen, serving food for about two million people each day. More than 50% of this is a part of children catering, including nursery, primary school, middle school and high school-level catering from 3 to 18 years old. Eating habits in childhood have a significant effect on the future generations’ health. Future generations’ labour capacity and state health expenditures have of great importance for the national economy.

1.2. Goals and hypotheses

G1: First goal of the research is to measure the physical and technical conditions of school canteens, and to evaluate the sufficiency of processes to be done by kitchen staff. It's important to evaluate the state of canteens in schools, and if there's a need for immediate, or mid-term intervention. Based on the results, factors could be identified which have significant impact on catering units differentiation. Notable question is wheter the technological and environmental *conditions* or the *processes* of right food handling practice have larger impact on food safety level.

G2: Second goal of the research is to evaluate the awareness of food handlers' food handling practice. Risks of knowledge gaps are evaluated mostly at kitchens operating as part of the public sector. Increasing awareness may improve the food handling practice of kitchen staff, the attitude of food handlers, and decreases risks of food safety management, while improving performance of public catering.

G3: The third goal is the quick evaluation of canteen hygiene using surface microbiology analyses. The knowledge of food handlers, and the micro-biological state of the kitchen surfaces are also on the focus of this research.

Hypotheses

H1: The technological level, and equipments have less impact on food safety than the appropriateness of food hygiene processes in catering kitchens.

H2: Food safety knowledge, and food handling practice of food handlers have a strong relationship, which means that if workers know how to do their task, they will do it properly.

H3: Parallel theoretical and practical training sessions can improve the food safety level of the catering units.

H4: Professional knowledge level of food handlers is influenced by the professional education and relevant work experience.

H5: The microbiological status of kitchen surfaces is strongly related with the theoretical knowledge of kitchen staff.

2. MATERIALS AND METHODS

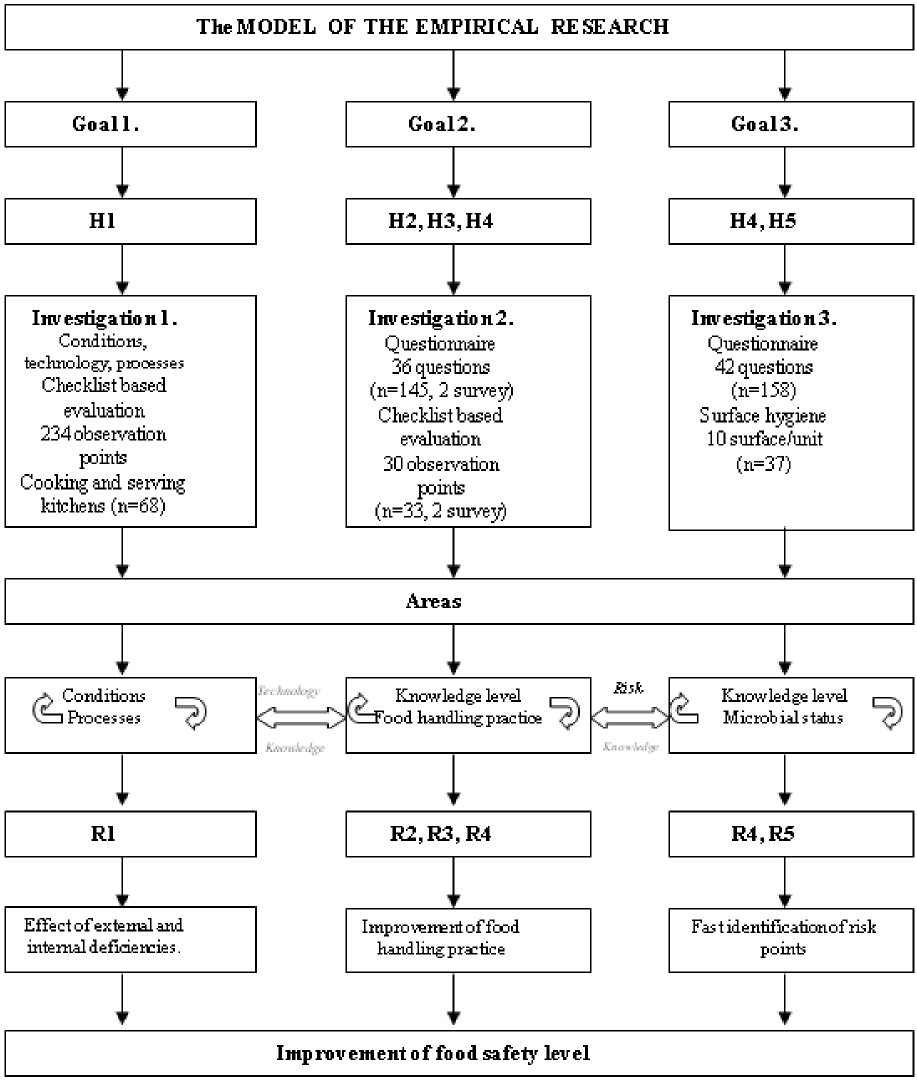

Figure 1: Model of the empirical research

Source: own processing

2.1. Study samples

The school catering units selected for the research were chosen among 120 units after asking for expert opinions, while keeping the internal ratios of Hungarian catering kitchens in mind. In the first quarter of 2014, 68 canteens were included in the sample (Analysis 1), and during spring 2015, analyses were conducted on 37 of the previously chosen 68 canteens (Analysis 2). In four instances, the analysis programme couldn't be finished, as such, 33 canteens yielded results subjectable to analysis. During the first half of 2016, 37 high school canteens were chosen again from the original 68 (Analysis 3).

2.2. Food safety environment and technological survey in school catering system

(Analysis 1)

The analysis was conducted during the first quarter of 2014. Most of the canteens (62) operate in Budapest, and less than 10% (6) were from rural regions. Of the institutions included in the analysis, 58 were under municipal supervision, and 10 were operated by churches / foundations. In order to determine the food safety level of the school canteens, a checklist was developed according to the international literature, keeping Hungarian specialities in mind. Food safety questions were fundamentally grouped into seven categories:

1. Physical establishment and environment
2. Kitchen personnel
3. Equipment and utensils
4. Receiving and storage
5. Preparation, service and cleaning
6. Quality assurance
7. Dining hall

As part of these groups, 42 sub-groups were defined, which included material and immaterial factors, functional and process-indicator factors related to the proper operations of the area. The questionnaire was made up of 234 questions. Among the surveyed catering units, 19 operated as cooking kitchen and 49 operated as serving units.

During the evaluation all "yes" answers were scored 1 and all "no" and "not relevant" answers were scored 0. Further on, weighting was carried out at three levels in the scoring system. It was necessary for two reasons: on the one hand, two different questions do not inevitably have the same importance from the standpoint of food safety, on the other hand, different number of questions should be answered in order to estimate different processes and conditions. The great number of questions is not characteristic of the significance of subgroups and hereby of the main groups; the number of questions raised was appropriate to clearly get the right answer. However, more questions will result in higher scores, for this reason weighting was used. The weight score of questions and question groups were determined by their importance for food safety, supported by expert opinions. As a baseline, questions related directly to food handling (examples are: preparation, hot holding, serving) were affixed with a higher weight number than those that can be viewed as extra processes (examples are: building, energetics, cleaning, dishwashing).

On the first level the questions were weighted (W_q), then the subgroups were weighted (W_s), and on the third level the main groups were weighted (W_m). Weighting was carried out on all levels by the following factors: normal=1, medium=2 and significant=3. Total score for the kitchen was calculated by the formula below:

$$TS=\sum(Q \times W_q \times W_s \times W_m)$$

where

TS: total score

Q: the score given to the question

W_q: weighting factor related to the question

W_s: weighting factor related to the subgroup

W_m: weighting factor related to the main group.

The resulted scores were divided by the theoretically maximal score, and the data so obtained expressed as percentages. A group of questions related exclusively to cooking kitchens (freezing of meals, delivery of meals, etc.). For this reason the scores of the kitchens were expressed as the percentage of the maximal scores of their own kitchen types.

Restructuring the checklist

When drawing up the checklist, it was an essential point of view that it should be filled in easily and quickly during the personal visits. However, the checklist has been rearranged according to the changes in the viewpoints of the evaluation. When arranging the new groups, questions related to the conditions and questions related to the processes have been treated separately. The following subgroups have been developed:

1. Building: technical conditions, energetics, public utilities, general technical condition, condition of the kitchen and the dining hall
2. Hygienic conditions: availability of the necessary conditions for keeping to food hygienic rules
3. Utensils: availability of the suitable technology and equipment/utensils

4. Hygienic processes: execution of the processes suitable to food hygienic rules in practice
5. Food handling: receipt of goods, keeping warm, repeated heat treatment, processes related to serving
6. Storage and preparation: processes connected with storing and preparing
7. Follow up: suitability of documentation of processes

Comparing cooking and serving kitchens

During the research, different checklists were used for cooking and serving kitchens, as there were several irrelevant questions for serving kitchens that were removed (examples are: preparation, cooking the dishes). As such, a valid question is the comparability of cooking and serving kitchen from a "professional" and a "statistical" perspective, as the number of questions isn't identical.

It is important to note that not only serving kitchens are different, but basically all kitchens are different to each other because there are no two perfectly identical catering units. If a question is not relevant for a kitchen, it was designated with n.a. (not applicable), and was removed from the statistical analysis (in order to make the analysis simpler for serving units, several questions were removed in advance). Naturally, total scores were defined by the number of questions used, meaning a correct or incorrect expert evaluation has different values for less, or more questions. The most important principle is that cooking and serving kitchens were competing not for the better, but for the good food safety level. This means that every kitchen's main goal is to reduce food safety risks, and maximise the health preservation of customers. As such, all catering units were competing for their own unique 100% result within their own environments, and with their own food handlers, and managing their own risks that come up during their processes.

2.3. Evaluation of food safety knowledge and food handling practice

(Analysis 2)

During the project lasting from January to June 2015, the knowledge and applied practices of food handlers were analysed. The results were used to assess lacking points and a special training programme was also based on them. The food handlers were educated within the training programme framework, both theoretical and practical. As part of a separate analysis, the changes in workers' knowledge and practices were evaluated once again. 37 kitchens took part in the project, of which, 33 yielded results usable for analysis. Of the participants, 13 were cooking, and 20 were serving kitchens. Cooking kitchens made the food on-site, serving kitchens received it from a contractor, and were only responsible for serving.

The project took 6 months, where the cooking, and serving kitchens were visited monthly, 6 times in total. The incentive was to have the written tests and observation analyses (1. and 6. visit) for the afternoon, in order to avoid the necessity of breaking work processes. Test writing sessions were scheduled without previous notifications, where food handlers completed them alone.

Trainings (2. and 5. visits) took two hours per session at most, the dates for these were specified in advance with the kitchens. It was important not to having too long courses. Another important factor was to discuss the lacking parts immediately on-site.

Evaluation and development of theoretical knowledge

Questionnaires were used to evaluate theoretical knowledge,. The questionnaire had 36 questions in 6 topics. The results were defined as a percentage of maximum score (36=100%).

Evaluation and development of food handling practice

The food handling practice of kitchens was evaluated with a checklist, which were completed by HACCP and food hygiene experts during on-site inspections. The practical checklist, similarly to the questionnaire consisted of seven topics with, 30 observation factors. Observation factors were scored by the hygiene experts on a 10 point scale (min. 1, max. 10), which was used to evaluate the results in percentage of the maximum (300=100%).

2.4. Analysis of the relationship between food safety knowledge and surface hygiene

(Analysis 3.)

Location and participants of the analysis

The analysis was conducted during spring 2016, with the aid of 37 school kitchens. Less than half of participants were cooking kitchen (n=17), where local cooking is done. The rest were serving kitchens (n=20), with only heating and serving functions, the food is distributed by external supplier. The schools serve only menu lunches, which were mostly (99%) hot food. Hot food makes for easy destruction of detrimental microbes through heating treatment. The greatest hazard after the last heating treatment comes from two main factors:

- Incorrect food handling process of food handlers
- Inadequate hygiene of food contact surfaces

The food hygiene practice of food handlers was evaluated with a knowledge test, whereas the hygienic state of the food contact surfaces were evaluated with microbiological analyses.

Knowledge test

The questionnaire consisting of 42 questions that was structured according to international model, and nothing was changed apart from translations. The questions measured five main areas of kitchen staff's knowledge, which were time- and temperature, cross-contamination, hand hygiene, cleaning and disinfection. A further 9 questions – which were significant for food hygiene, but do not to the four aforementioned areas – were added to an 'other' category. The food handlers participated in this survey (n=158) were worked as catering manager, storage manager, cook and kitchen maid.

Surface hygiene analyses

Sampling was performed on 10 different surfaces by rubbing for 20 second with sterile collection swabs. The surfaces of study were on spoons, forks, knifes, soup plates, dinner plates, dessert plates, kitchen tables, serving utensils, catering trays and drinking glasses. Samples were taken from 100 cm^2 of each surface, except for the spoons, forks and knives for which measurements were performed on three different items each time. After collection, samples were transferred to the lab, where microbiological analyses were applied.

The total bacterial count on the surfaces was determined using the MICROTESTER appliance based on redox potential measurement. The theoretic basis of the measurement process is that during bacterial proliferation, energy-producing bio-oxidation reactions decreasae the environment's redox potential that is easily detectable above a certain threshold of microbe concentration. The time for detection (TTD) is the time, where the absolute value of redox potential change exceeds a value significantly differing from coincidental effects (e.g. $|dE/dt| \geq 0{,}5$ mV/min). This value is called detection criterion. Standard microbiological media could be used with the MICROTESTER appliance as well. The redox curves of differing microbe groups are also different to each other. As such, this method occasionally allows for not only detecting bacterial proliferation, but also identification of the microbes. The measurement was conducted by placing the different surface tampons into the measurement cell, and detection time was determined by the MICROTESTER appliance.

2.5. Statistical methods used for evaluation

Summary of the methodology used to validate dissertation hypotheses were summarised in table 1.

Table 1: Framework of the empirical research

<table>
<tr><th>Data</th><th>Goals</th><th colspan="4">Research tools</th><th colspan="3">Results</th></tr>
<tr><td rowspan="6">Primary data</td><td>---</td><td colspan="2">Hypotheses</td><td>Methods</td><td></td><td>---</td><td></td><td rowspan="6">Conclusions</td></tr>
<tr><td>G1</td><td rowspan="5">Literature review</td><td>H1</td><td>Linear regression</td><td>→</td><td>R1</td><td>→</td></tr>
<tr><td rowspan="3">G2</td><td>H2</td><td>Pearson’s correlation</td><td>→</td><td>R2</td><td>→</td></tr>
<tr><td>H3</td><td>Welch test, dual-sample (unrelated) T-test</td><td>→</td><td>R3</td><td>→</td></tr>
<tr><td>H4</td><td>Dual-sample (unrelated) T-test, General Linear Model test</td><td>→</td><td>R4</td><td>→</td></tr>
<tr><td>G3</td><td>H5</td><td>Linear regression</td><td>→</td><td>R5</td><td>→</td></tr>
</table>

Source: own processing

3. RESULTS

The next chapter shows the results of data evaluation the three analysis phases.

3.1. Comparison of the food safety level of cooking and serving kitchens in Hungary

Evaluation of checklists

The survey had questions that were applicable only for cooking kitchens, and irrelevant for serving kitchens. In order to better facilitate comparison, the results of the kitchens were defined in the percentage of theoretic maximum score. The questionnaire can serve as a basis for qualitative results related to the kitchens. The most common problem was the incorrect treatment of food waste, and lack of tools for hot holding and reheating. A special problem for cooking kitchens was the incorrect documentation of food delivery. The average performance of kitchens was 68%. After leaving out extremities, kitchens were divided into three equal group, as good, average, and bad.

Comparison of cooking and serving kitchens

Due to the different structures of the checklists, the cooking and serving kitchens were evaluated separately. The theoretic maximum score achievable by kitchens was 2029, whereas serving kitchens could reach up to 1845. The results show that the hygiene and food safety level of cooking kitchens was better overall. The majority of cooking kitchens's results were between 70-90%, whereas the performance of serving kitchen reached only up to 60-80%, but a significant number got scores below 60%.

Process-oriented analysis

When restructuring the checklist, questions were grouped according to reflecting to a state, or to a process. The main groups 1-3 consist of the attributes, whereas main groups 4-7 reflect the processes that happen in the kitchens. The forming of new groups had no effect on either the weighting of the questions, or the original scores, which means the order of kitchens remained the same.

When evaluating the physical environment, work areas and service zones, walls, windows, the roofing and the floor, the energy- and water supply, and the ventilation were the main concerns. Further analysis was conducted on the conditions for waste storage in accordance with regulations. When evaluating the tools and appliances, the main focus was on the state of kitchen furniture and tools used for everyday operations. The physical environment analyses' average was 70%, whereas tools and appliances reached 67%. There is no statistical difference between the two factors (T-test: $p \leq 0,05$), however, correlation can be observed. The tools and appliances used in kitchens that were in a better state were generally better as well ($r=0,783$, $p<0,001$). During correlation calculations, there was no significant relation either between the factors of various processes or the processes and the evaluations of current state (places, tools and appliances).

Effects of process-oriented modules on food safety

The goal of the analysis is to determine how large impact on a kitchen's food safety level have the different factors, based on the scores achieved during the survey. The analysis was conducted using linear regression, where the independent variables' effect on placement within groups was analysed. In order to better facilitate comparison between cooking and serving kitchen, the results of surveys were normalised, for which question group 'food storage' was removed, which served to analyse storage and preparation. After excluding the points of factor 6, the scores of the cooking and serving kitchen re-summarised, which didn't result in a large difference in order. The maximum theoretic score reached up to 1845. The determination coefficient (correlation coefficient squared) showed how much of the variability of the total score is explained by the dependence on factor. The determination coefficient was highest for the Handling of food and Hygiene processes factors. It was lowest for the Hygiene conditions factor. According to results, the technical quality and appliances of a kitchen had less impact on the sufficiency of tasks to be done, and through it, the food safety level of the kitchen. In case the minimum appliances are at hand, even a less adequate kitchen can be operated on sufficient quality level. The key for sufficiency is the correct food handling practice, attitude and behaviour of kitchen staff.

3.2. Measuring and developing awareness for food handling practice

The theoretic analysis showed the direction and level of development individually. Meanwhile, the observation of the correct practice by institution and the kitchen staff's work are evaluated in a summarised manner. After the first analysis, all kitchen staff took part in a hygiene training. Skilled jobs were filled with qualified workers.

The kitchens had 99 people, whereas the canteens had 46 people working as food handlers. A majority of the participants (85%) were female. 75% of those food handler were above age 40. 66% of the workers were kitchen maid, the serving kitchens employ only kitchen assistants. 74% of the workers had no catering-related education. 40% of the workers had less than 1 year of work experience on the field. 137 people participated in filling the knowledge questionnaire on the first occasion, and 143 on the second. All the storage management staff and cooks were at least age 30. Among the catering managers, there were none below age 40, and everyone had at least 5 years of work experience on the field.

Identifying the knowledge gaps of food hygiene

The average value for all kitchen staff pre-training resulted in 67.4%, the deviation of the results were 10,2%. Kitchen staff achieved the highest score for personal hygiene (80.6%), which was coincidentally the only field they managed to overcome the 80% threshold. Knowledge scores were between 70% and 80% for cleaning (78.7%), food waste (77.7%) and serving (73.1%). Dishwashing (65.1%) and storage (59.5%) reached very low results. The results for receiving (50%) was simply worrying. One notable conclusion is that the areas with less processes had better, whereas those with more processes tended to have worse performances from kitchen staff. Less regulations related to personal hygiene– most of them are similar to everyday behaviour – when compared to delivery receiving, where checking the sufficiency (traceability) requires a high level of precision.

Based on the answers to all questions, the group that reached higher scores were the **cooking kitchen staff** (difference between types of kitchens was significant at 5% margin), however, only three of the seven areas had significant differences (treatment of food waste, specified storage and delivery receiving). The results off serving kitchens are higher only for one topic of seven (serving – heat re-treatment), even if not significant.

Identifying the lacking points of food handling practice

Lacking points in practical knowledge mainly revealed where the practice differed from that of a normal household. A common problem is that knowledge brought from home was applied to their workplace practice, which also showed in the practice of food handling.

The 33 kitchens reached 71.7% scores on average during practical tests, deviation capped at 7.51%. The worst-performing kitchen got 52%, whereas the best-performing achieved 84% during evaluations. The most adequate area, reaching above the 80% threshold was receiving (81.92%). Between 70% and 80%, we could find cleaning (74.24%), personal hygiene (77,27%), serving – reheating (71.87%) and food waste handling (77.58%). Storage (57.69%), where cross-contamination prevention and its consequences were notable, and dishwashing (53.18%) method had results below 60%, considering them as high-risk factors. In food handling practice, even if any processes were done according to regulations, awareness and cause-effect correlations were observed rarely. Kitchen staff didn't have opportunities to learn these competences due to lack of training. Inspections were almost exclusively done by the authorities, but even these aimed only to discontinue detrimental practice, and didn't consider background knowledge, and explore the causes. Whether in official or internal audits, the focus was not on accountability and building fear and not on helping or expanding knowledge. The T-test showed significant difference only between the cooking and serving kitchens in the area of dishwashing (p=0.033).

Determining theoretical and practical training programmes' contents

When creating training guidelines, considerations for the lacking areas of theoretical knowledge, and / or applied practice were made. These mainly focused on the areas where processes were not understood, and incorrectly applied practice was prevalent. The training considered points that were specifically tailored for each kitchen. These checkpoints were determined in accordance with the regulations of "Útmutató a vendéglátás és étkeztetés jó higiéniai gyakorlatához" (*Guideline to the proper hygienic practice of catering and restaurant service*; NÉBIH, 2013).

Changes in results of knowledge

By the second evaluation, knowledge level has been significantly but slightly improved..

Average scores between the two occasions changed significantly (though not to a great degree), usually increased. The most notable improvement was revealed in case of food waste (12,4%), which was followed by personal hygiene (8,0%), cleaning (7,6%) and dishwashing (7,5%). Exceptions to the significant increase were: receiving, where there was no significant improvement, and storage, where change was significant, however, showed decrease (-5,7%). Later, it became apparent that this was caused by serving kitchen staff, to whom this set of questions were not relevant in everyday practice.

The comparison between cooking and serving kitchen during the second instance was similar to that of the first, in terms of them having a difference in total score and the same three factors (food waste handling, storage, and delivery receiving). However, one difference is that the total scores for the two groups are significantly higher.

The 1+7 average scores calculated from the entire questionnaire, and the 7 question group by participant correlated significantly to the number of years spent in catering service in several cases. The correlation coefficients were positive as expected, but the correlation showed was not too noticeable: just the correlation for the entire questionnaire's average score has a coefficient above 0,3.

Changes in practical results

Significant results could be seen in changes of practice applied. The average of the kitchens for the entire measurement improved by 13.05% between the two instances. For specified storage (30.77% improvement), correct labelling and specific selection according to level of contamination were keys to achieving such striking change. Correct tool utilisation, correct calibration of dishwashers and cleaning agents and the outlining of a cleaning plan were behind changes for dishwashing and cleaning.

For the areas of serving – reheating, and receiving, the key was the measurement and tracking of temperatures, correct handling of products during delivery, and the proper tracking practice were what facilitated improvement. Both in tool utilisation (core thermometer), and in administration (filling out the serving and temperature registry forms), kitchens showed improvement. The only area where significant improvement could not be detected was food waste handling.

If we consider averages for the various kitchens for 7 (and in case of serving kitchens, 6) practical evaluations, we can see that the final evaluation became better for every participating kitchen.

Comparing knowledge and applied practice

In order to compare the theoretic knowledge to practice, the average scores of kitchen staff by workplace were given an X value, and the average evaluation percentage got a Y value for both tests, expressed in coordinates for values that paired. The figure clearly shows that knowledge and practice do not correlate with each other in either occasion, there are several kitchens that had good values in one aspect, and bad in another.

3.3. Relation of food safety knowledge, and the microbiological status of food contact surfaces in school catering

Evaluation of food handlers' knowledge

Based on the test results, knowledge index were used to determine knowledge of kitchen staff. This was constructed with a 42-question test, and results were expresserd in the percentage of maximum theoretical score. The average was 84.84%, deviation was 12.28%, and interval was 26.19% - 100%. Comparison of two groups for the average values resulting from the knowledge index averages used to determine professional knowledge level of kitchen staff partial samples – in case the knowledge index's values showed normal separation by partial sample, or the sample sizes of partial samples were large enough – were analysed for two groups using T-test, and for more than two groups, one-factor variance analysis. The variances by group were compared in the framework of the variance analysis using Levene trial.

Kitchen type

Based on the two-sample (independent sample) t-test, no significant differences (p=0.932) were found when comparing the knowledge level of the workers at cooking units and at serving units. In a serving kitchens only kitchen maid works as staff, and most of the staff is unskilled employees without any professional knowledge. The operators realised this risks, therefore in serving kitchens that operates with 2-3 people, with the aim to employ at least a single person who has professional qualifications. We may assume that this is the reason for the lack of difference between test results.

Age groups

A significant difference (ANOVA: $p<0.01$) was found when comparing the younger (15-29 years old) and older groups (40-49 years old and ≥50 years old) of kitchen workers according to their knowledge test results. A t-test conducted for two age groups (up to 35 years and over 35 years) revealed ($p=0.002$) that the knowledge level of younger workers was significantly lower than the level of the workers over 35 years (data not shown). The Classification and Regression Trees (CRT) analysis revealed the characteristics that contribute significantly to the different performance of the two groups at the test (workers achieving 90% or over and workers achieving 90% or less). According to the CRT model, the age variable was found most suitable to separate the groups of workers who achieved performance level of at least 90% and the group of workers who performed below 90%; in the group of workers who were under 35 years old, a greater proportion of them failed to reach the level of 90% compared with the sub-group of over 35 years old.

Position

Based on the results of ANOVA ($F=1,839$, $p=0,142$), no significant difference appears between catering managers and storage staff, cooks, or between storage managers, cooks and kitchen maids.

Education level

The education level of kitchen staff showed no significant difference (ANOVA: $F= 1,204$; $p=0,310$) on professional knowledge level. Furthermore, there's no significant difference between primary or basic, or intermediate or higher education levels either (T-test: -0,328; $p=0,743$). In the group of those above 35, those that have higher education all reached 90% performance. Higher education increased success during the test for the older kitchen staff, but didn't show up as a positive factor for those younger.

Professional training

There is significant relation between professional qualifications and professional knowledge: those that had no professional training finished had lower average scores compared to those that do (T-test=-2.962, $p=0.004$).

Work experience

There's a tendency-level relation between work experience and professional knowledge (ANOVA: F=2.516; p=0.060): the knowledge index's average value is significantly higher for those that have 6-10 years of work experience compared to their colleagues who only have two. Further analyses also support this claim, the general linear model (GLM) resulted in a 9.13% decrease in the scores of those that have less than two years of work experience, based on the professional knowledge index.

Recording the calibration curve

The redox potential change caused by bacterial growth is usually characterised by a spike increase in redox potential decrease speed above a certain culture size. The time necessary for this to happen is inversely proportional to the starting cell quantity. Redox potential measurement can be applied to samples which also have calibration data. Therefore, all the samples that were never subject to analysis have to be first added to a calibration curve. However, this work requires a laboratory. The calibration curve can be determined using the MN EN ISO 4833-1:2014 total microbe count standard, using the successive dilution data of microorganism samples taken from the different surfaces. A successive dilution row is made from the kitchen surface samples expected to be contaminated by microbes, which had its total microbe number analysed using classical culturing method. After injecting the members of the successive dilution row into the MICROTESTER's measurement cell, the TTD value was determined. The IgN and MICROTESTER-measured TTD values obtained by culturing were used in linear regression to calculate the equation of the calibration curve. The calibration curve for kitchen surfaces is as follows: $lgN = 8.6519-0.4421\times TTD$

Evaluating the micr-biological state of food contact surfaces

The number of living microbes (mesophil aerob bacterial count) on all food contact surfaces was between 0 – 9.1×10^6 CFU/100 cm^2. The medians of microbe quantities in the 37 schools' different surfaces showed significant differences in values. For the kitchen table, 3100 CFU/100 cm^2, for the canteen tray, 1600 CFU/100 cm^2, for the serving tools, 480 CFU/100 cm^2, for the bowls, 410 CFU/100 cm^2, and less than 90 CFU/100 cm^2 for the rest of the utensils. When evaluating food contact surfaces, three groups were defined. The low-risk group were where the microbe count was below the Hungarian threshold (<250 CFU/100 cm^2), the medium risk group had a microbe count between 250–5000

CFU/100 cm^2, and the high health risk group was the one above this (>5000 CFU/100 cm^2). These value thresholds more or less match international values, however, we can see significant differences by countries as well. Based on the results, 16 of the kitchens (43.2%) had kitchen tables in the high health risk category. Similarly, high health risks were found in the bowls of 15 kitchens (40.5%), the canteen trays of 13 kitchens (35.1%), and the service tools in 13 kitchens (35,1%). Of the rest of the surfaces, glasses, saucers and plates of 10 kitchens (27%), and spoons, forks and knives of 6-9 kitchens (16.2-24.3%) were of the high health risk group.

Correlation between microbiological status of food contact surfaces and knowledge

The food hygiene knowledge in kitchens, and the microbiological state had statistically significant correlation ($r^2=0.9303$; $P<0.001$).

The theoretic questions related to microbiological cleanliness mainly belonged in the "Time and temperature" and "Cleaning and disinfection" question groups. Interestingly, these two question groups were generating the most problems for the kitchen staff. By making use of food safety training, the hygiene performance level of kitchens can be improved, and the microbiological load on kitchens can be reduced by up to 45-60%.

4. HYPOTHESES' VALIDATION, NEW AND NOVEL SCIENTIFIC RESULTS

Hypotheses are validated below in Chart 2.

Chart 2: Hypotheses' validation

Results	**Hypotheses**	
R1	H1	valid
R2	H2	invalid
R3	H3	valid
R4	H4	valid
R5	H5	valid

H1: The technological level, and equipments have less impact on food safety than the appropriateness of food hygiene processes in catering kitchens.

The analysis validated H1, according to which (in case the technological minimum requirements are met,) the main determinant of the food safety level of kitchens is the pair of food handling practice and food hygiene process. Kitchens with a good food safety score had significantly higher ratings for food handling practice. I suppose that the **food safety level of kitchens can be increased by improvement of the knowledge and awareness of kitchen staff**. Serving kitchens especially need a lot of attention.

H2: Food safety knowledge and food handling practice of food handlers have a strong relationship, which means that if workers know how to do their task, they will do it properly.

The analysis proved H2 to be invalid. Theoretic knowledge and food handling practice have no correlation. In light of this, we cannot assume that if a kitchen staff knows the proper regulations for food hygiene, they will automatically perform their duties correctly. Even if a kitchen staff theoretically understands proper hygiene regulations, its proper application is not guaranteed.

H3: Parallel theoretical and practical training sessions can improve the food safety level of the catering units.

The analysis found H3 valid. After the special training programme, although to a lesser degree (3.4% score), the theoretic knowledge increased significantly. More prominent results were achieved on the field of food handling practice, kitchen's managed to improve to an average of 13.05% score. However, beyond the expansion of theoretic and practical knowledge, constant repetition is mandatory. Besides regular inspections, testing and evaluation of employees are also necessary.

H4: Professional knowledge level of food handlers is influenced by the professional education and relevant work experience.

The research found H4 valid. The knowledge test's results showed that those that have no professional training generally got lower scores than their colleagues that own relevant competences (T-test, p=0,004). Relevant work experience provided an average of 9.13% less score for 2 years and below, based on the professional knowledge index's results. In Hungary, the jobs in 6500 canteens need no professional training, and in light of the results, the regulatory system should be rethought.

H5: The microbiological status of kitchen surfaces is strongly related with the theoretical knowledge of kitchen staff.

It was found that H5 is valid. The kitchens' food hygiene knowledge and micro-biological state had strong correlation, based on the calculation ($r^2=0.9303$; $p<0.001$).

New and novel scientific results

R1: The food safety level of a catering canteen is primarily defined by the food handling practice, and the sufficiency of hygiene processes. It is also less affected by the technical quality and technological appliance availability.

Publications related to the result: 6, 7

R2: The development of kitchen staff's theoretic knowledge alone isn't sufficient for improving food safety level.

R3: Using a five-time on-site special training programme, the food handling practice of kitchen staff can be significantly improved, which can reduce the food safety risk as a result of their work.

Publications related to the result: 4, 5, 6, 10

R4: The professional training of kitchen staff has significant correlation with their professional knowledge level. Work experience and professional knowledge level have tendency-level correlation.

Publications related to the result: 2

R5: An entirely new analysis method, with which the cross-contamination and the risk points of microorganisms can be measured and overseen in the operations of school canteens. Using the process, quick and simple quantification (6-12 hours) of microbe counts on various surfaces is possible. This allows for the identification of lacking parts within kitchens' hygiene qualities. Using the process, author revealed that the lack of knowledge of kitchen staff and the microbiological state of kitchens have strong correlation with each other.

Publications related to the result: 2, 3, 13, 15

5. Conclusions, recommendations

The research showed for the insufficient food safety level of the kitchens Municipalities have tasks beyond financing the excess costs that go over ingredient cost norms – they also have to assure proper environments. This would cause almost all the operating institutions significant excess expenditures, as few of schools operate with adequate conditions. Authorities create the regulatory environment in vain, school canteen’s do not work in a healthy manner, or abide by said regulations just because of that. Reason being, neither the environment, nor the tools, or even the process handling are how the requirements of proper food handling practice would need them to be. Based on the research results, it would be necessary to conduct measurements for all the cooking and serving kitchens involved in children catering in Hungary, for which the methodology introduced in the dissertation may prove helpful.

Overseeing food safety, development of proper food handling practice, and the success of professional and authorities working in the field are often remain invisible. There are domestic and international statistical data for food borne diseases, but they only show the tip of the iceberg, and several other factors (more consumer awareness, increasing discipline for reporting, electronic information systems) are affecting them. Everyday interventions made by food safety experts are a huge array of invisible factors enforcing proper hygiene practice. As such, it would be erroneous to conclude that food safety interventions’ efficiency is directly related to the number of sickness cases. The task of professionals is to reduce risks, or to simplify, those working on the field of food safety did a proper job in case there was no instance threatening human health. In conclusion, efficiency of food interventions can mainly be increased by making risk identification and more efficient management.

In light of the above, author believes that the development of food handling knowledge and practice, and the MICROTESTER based surface analysis used to quickly and cheaply find food safety risks shown in the dissertation are and easily applicable methods. The data of cooking and serving kitchens in the analysis, and the conclusions drawn from the data can be used as the basis for further research as well.

6. PUBLICATIONS RELEVANT FOR THE DISSERTATION

Articles in foreign language:

1. Dunay, A., Kovács, A., Illés, B. Cs., **Tóth, A**., and Bittsánszky, A. (2019): Food allergy and food intolerance knowledge of foodservice workers in Hungarian schools. *POTRAVINARSTVO / SLOVAK JOURNAL OF FOOD SCIENCE,* 13:(1), pp. 318–324., doi:10.5219/1111. Scopus Q3
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3. **Tóth, A. J**., Szakmár, K., Dunay, A., Illés, B. Cs., and Bittsánszky, A. (2018): Hygiene assessments of school kitchens based on the microbiological status of served food. *ACTA SCIENTIATUM POLONORUM TECHNOLIA ALIMENTARIA*, 17:(2), pp. 159-168., doi:10.17306/J.AFS.0564. Scopus Q3
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5. Bittsánszky, A., **Tóth, A. J**., Illés, B. Cs., and Dunay, A. (2015): Knowledge and practice in food safety processes - a case study on Hungarian school catering. *INTERNATIONAL JOURNAL OF INNOVATION AND LEARNING*, 18:(3), pp. 380-396., doi:10.1504/IJIL.2015.071554. Scopus Q3
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Books, book chapters

10. **Tóth, A. J.,** Bittsánszky, A., Dunay, A., Lehota, J., and Illés, B. Cs. (2015): Élelmiszerbiztonság menedzsment az iskolai konyhákon. In: Könyves, E., and Lehota, J. (eds) Élelmiszerbiztonság menedzsment az iskolai konyhákon, (pp. 143-162.) Debrecen: Debreceni Egyetem Gazdaságtudományi Kar, 192 p.
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Conference materials in foreign language

12. **Tóth, A. J.,** Kovács, A., Törőné Dunay, A., Illés, B. Cs. and Bittsánszky, A. (2019): Traceability and cross-contamination – Food safety knowledge of Hungarian foodservice workers. In: Illés, B. Cs. (ed.) Proceedings of the International Conference on Management: "People, Planet and Profit: Sustainable business and society": Volume I, (pp. 374-382.). Gödöllő: Szent István Egyetemi Kiadó, p. 385, doi:10.17626/dBEM.ICoM.P01.2019.p106
13. Kovács, A., **Tóth, A.**, Dunay, A., Illés, B. Cs. and Bittsánszky, A. (2019): Meat analogues as protein sources. In: Dunay, A. (ed.) Proceedings of the 9th International Conference on Management: "People, Planet and Profit: Sustainable business and society": Volume II, pp. 370-376., Gödöllő: Szent István Egyetemi Kiadó, p. 407, doi: 0.17626/dBEM.ICoM.P02.2019.p107
14. Illés, B. Cs., **Tóth, A. J.**, Dunay, A. and Bittsánszky, A. (2018): Pilot-study for the measurement of consumed food in school cafeterias. In: Bylok, F., Albrychiewicz-Słocińska, A., Cichoblazinski, L. (eds.) 8th ICoM: Leadership, Innovativeness and Entrepreneurship in a Sustainable Economy: Book of Proceedings, pp. 280-285., Czestochowa, Poland: Wydawnictwo Wydzialu Zarzadzania Politechniki Czestochowskiej, p. 723
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22. **Tóth, A. J**., and Bittsánszky, A. (2014): Tudatos élelmiszerkezelési gyakorlat a közétkeztetésben. In: Solt K. (szerk.) Alkalmazott tudományok fóruma, pp. 950-961., Budapest: Budapesti Gazdasági Főiskola, 2014. március 13-14.

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